

# CYTOLOGICAL AND ECOLOGICAL NOTES ON THE TARAXACUM SECTIONS ERYTHROSPERMA AND OBLIQUA OF THE COASTAL AREA OF THE NETHERLANDS

J. C. M. DEN NIJS, A. A. STERK and H. VAN DER HAMMEN

Hugo de Vries-Laboratorium, Universiteit van Amsterdam

## SUMMARY

In this first publication of a series reporting on the results of a biotaxonomic and ecological research project concerning the genus *Taraxacum*, cytological and some oecological data are recorded of 13 species belonging to the sections *Erythrosperma* and *Obliqua* from the dune area of the province of N. Holland and from the North Sea island of Terschelling (The Netherlands), are recorded. In most of the population samples from 4 to 8 different species were found. The populations from the mainland proved to be richer in species than those of Terschelling. Some ecological and possible genetic implications of the sympatric occurrence of so many species in the same habitat are discussed.

The chromosome numbers of *T. commixtum* ( $2n = 24,32$ ) and of *T. laetiforme* ( $2n = 24$ ) had not previously been determined. In four other species chromosome numbers were found which differ from counts of the same species as reported in the literature. Both the local and the regional karyological variation are appreciable. There is a remarkable concentration of (newly recorded) tetraploid forms in a restricted area within the mainland area studied.

A study of the chromosome morphology revealed a most inconsistent pattern of satellites and secondary constrictions within a single species, involving both their number and their size or location. In the discussion some attention has been paid to the conceivably erroneous reports in the literature of hypertriploidy which may be attributable to this inconsistency of the chromosome morphology.

## 1. INTRODUCTION

The taxonomic complexity of the genus *Taraxacum* with some 40 sections and about 2000 described (micro)species in a polyploid series (with  $x = 8$ ) is an established fact; for surveys compare, e.g., DOLL 1973a, b, 1974; RICHARDS 1968, 1970b, 1972; RICHARDS & SELL 1976 and VAN SOEST 1963. An important and basic feature with taxonomic implications is the frequent incidence among the polyploid species of obligatory agamospermy supposed to be responsible for a complete genetic isolation of closely related species providing the basis of the morphological, ecological, and phytogeographical identity of the species. However, already as early as 1946 SØRENSEN & GUDJONSSON showed that in the agamospermous triploids ( $2n = 24$ ) occasionally sexual reproduction, and consequently an exchange of genes, may take place. In addition one has found that also outside of the western part of central Asia (considered to be the area of origin of the genus, VAN SOEST 1958) diploid and sexually reproducing taxa occur; this has been demonstrated for Central Europe by TSCHERMAK-WOESS (1949), FUERNKRANZ (1960); for Britain by RICHARDS (1968, 1970b) and for northern Europe by

GUSTAFSSON (1937), MALECKA (1961). The incidence of sexual reproduction may have a considerable bearing upon speciation processes and upon the classification. A more detailed discussion of this point is beyond the scope of the present paper, but the insufficient knowledge of the distribution of sexual forms of *Taraxacum* in the Netherlands and in a wider compass, in Europe (compare RICHARDS 1968), which renders the classification more or less uncertain and the cause of variation difficult to assess, has also been a reason why the present study was initiated; this paper is the first report of our findings. Our second consideration was that the appreciable range of forms encountered especially in more or less anthropogenic habitats and expressing itself in such a fashion that in the Netherlands a meadow rich in dandelions may contain 10 to 15 microspecies of the section *Vulgaria* renders a detailed study of this phenomenon necessary (VON HOFSTEN 1954 recorded similar situations in Sweden). From an ecological point of view this poses several problems, especially that of the co-existence of so many closely allied taxa in the same habitat, and the question what underlying mechanisms of niche differentiation are involved. SOLBRIG & SIMPSON (1974) succeeded in demonstrating in the U.S.A. differences between closely related biotypes of *Taraxacum* as regards their life strategy in connection with r- versus K-selection. It is not very probable that the co-occurrence of a number of closely related species of dandelions in a certain type of environment is chiefly explicable by the heterogeneity of that environment.

In order to get a better insight into the distributional range, the ecological tolerance, and the habitat preference of the microspecies of *Taraxacum* in the Netherlands, an inventarisation of various environments was started. On the basis of population samples, the relative opulence of the *Taraxacum* flora is being investigated. In addition ecological data concerning the vegetation, the soil conditions, and the agricultural management were assembled.

It is to be expected that the assembled evidence will enable us to assess the significance of the *Taraxacum* flora and also to what extent the dandelions are indicative of ecological conditions. Such information may prove to be very useful for the future management of pastures and meadows and also of nature reserves.

The present report concerns only the chromosome numbers and the cytological variation of a number of species of the sections *Erythrosperma* Dahlst. em. Lindb.f. and *Obliqua* Dahlst. em. Lindm. found in the coastal dunes of the province of North Holland and of the North Sea island of Terschelling. The ecological aspects will only be touched upon here in a preliminary way and will be treated extensively in forthcoming papers.

Our information concerning the chromosome numbers in the species of the sections *Erythrosperma* and *Obliqua* is still very incomplete, and when they were recorded the data were usually obtained from only a few localities (or from a single one), and from a few individuals. A survey of the accumulated records is given in our table 2 (compare also DOLL 1973a). Material from the Netherlands had previously only been investigated by HOU-LIU (1963). The available data already point to a certain amount of regional, and partly also infraspecific, cytological differentiation.

## 2. MATERIALS AND METHODS

The sites that were sampled are situated in the Noordhollands Duinreservaat (Prov. of Noord-Holland) and in the island of Terschelling (Prov. of Friesland). For the localities, see *map 1*.

The population samples were taken from as many different environments as possible so as to be able to study the greatest possible range of diversity in the local species of *Taraxacum*. At each selected site 50 to 100 *Taraxacum* plants were gathered from the local population. With "local population" is meant a group of flowering and/or fruiting specimens of *Taraxacum* occurring in an ecologically discernible part of the terrain, such as a slope with a northern or an eastern exposition in the dunes. The actual sampling was done as follows: A length of rope was placed on the vegetation cover in several repeated runs and each generative dandelion plant touched by the rope or growing at a distance of not more than 10 cm from the rope was collected. The number of runs was determined by the surface area of the locality and the density of the *Taraxacum* stand. At each sampling site a record of the stand of vegetation was made according to the method of the Braun-Blanquet school (see DOING KRAFT 1954). These records will be published elsewhere. For the identification of the species the keys of HAGENDIJK et al. (1975) were used. The names of many collected specimens (including all those used for our cytological studies) were checked by A. Hagendijk, Prof. J. L. van Soest and H. A. Zevenbergen. For the nomenclature of the other higher plants encountered in our sample plots HEUKELS-VAN OOSTSTROOM (1975) was followed and for the syntaxonomic units WESTHOFF & DEN HELD (1975).

Chromosome counts were obtained by means of a squash technique, mostly applied to young seedlings and partly to root tips of plants transplanted into flower pots (compare, e.g., RICHARDS 1968, DEN NIJS 1974, somewhat modified). Of all plants cytologically studied voucher specimens are kept in the herbarium of the Hugo de Vries-laboratorium (AMD).

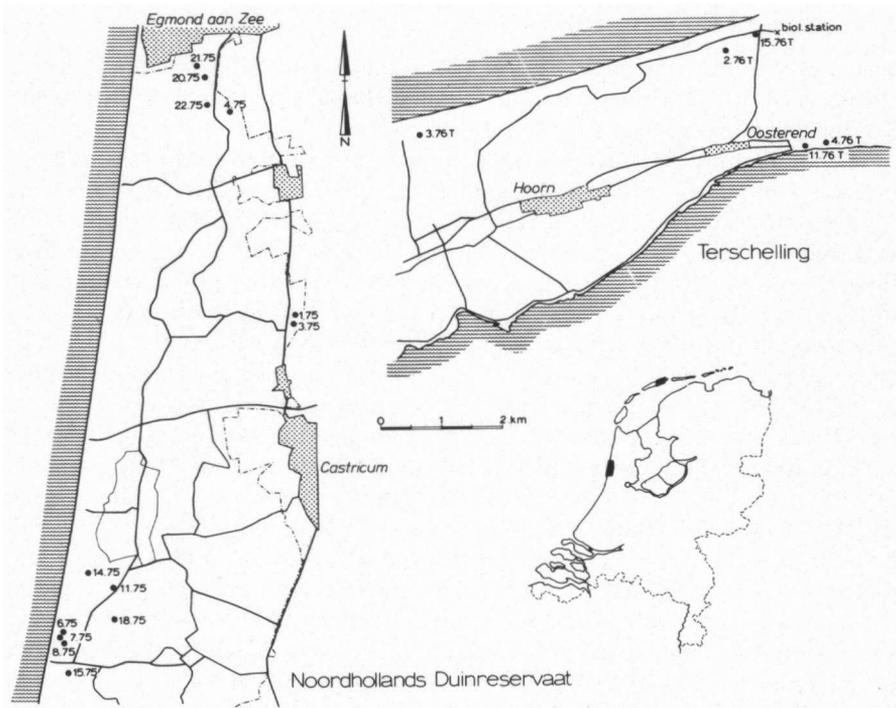
## 3. DESCRIPTION OF THE SITES

Many ecological details have been borrowed from DOING (1964, 1966). An attempt was made to classify the vegetation records according to WESTHOFF & DEN HELD (1975), but this was not always possible, however, owing to the appreciable local variation of dunal vegetation types.

The areas where samples were taken can be referred to the following four groups (compare *map 1*):

### 1. *The Vroonweiden (= statute pastures) near Castricum*

The population samples 1-75 and 3-75 (*table 1*) were collected in a complex of former statute grassland near Castricum (Bakkum) locally known as "Koningsbosch", consisting of partly low-lying and moist grassland, grazed of old but nowadays only extensively so. It is situated along the low inner border zone of the dunes in the transitional zone towards the flat arable land.



Map 1. Situation of the sampled populations.

The soil is comparatively rich in humus and decalcified. The local stands of vegetation are characterised, among other things, by acidophilous taxa such as *Anthoxanthum odoratum*, *Agrostis tenuis*, and *Rumex acetosella*, and they exhibit some ruderal features. The vegetation types are referable to the *Galio-Koelerion* and show a relation with the *Festuco-Galietum maritimi* (WESTHOFF & DEN HELD 1975).

### 2. Outer dunes "Oceaan" near Heemskerk

The population samples 6.75, 7.75, 8.75, 11.75, 14.75, 15.74 and 18.75 were obtained from the dune area Oceaan near Heemskerk. This is a relatively undisturbed area consisting of fairly young dunes. The soil contains only a thin layer of humic matter and somewhat deeper a great deal of shell grit rendering it rich in lime. The whole area has been described by DOING (1964) as the *Rubus caesius*-landscape with, dependent on the exposition, transitions towards the *Ammophiletum* and *Galio-Koelerion* vegetation.

### 3. Inner dunes in the vicinity of "Aldertdal" near Egmond-aan-Zee

Population samples 20.75, 21.75 and 22.75 were gathered about 1 km South of Egmond aan Zee in the "Aldertdal" and surroundings. This area has of old been

subjected to some anthropogenic influences and is consequently covered by a somewhat singular vegetation type included by DOING (1964) in the *Koelerion-Silene* landscape, a type generally developed around the old fishing villages in the dune region. The samples studied are from stands of the *Anthyllido-Silenetum* or closely related vegetation types. The sample 4.75 is from the Bleek near Egmond aan Zee, an almost level stretch of ground situated in the transition towards the inland agricultural fields and meadows. This site is disturbed to some appreciable extent by treading.

#### 4. Dunes in Terschelling

The dunes of Terschelling are situated in the so-called Wadden District and are poor in calcium, whereas the other localities enumerated are all in the calcareous Dune District (see HEUKELS-VAN OOSTSTROOM 1975). The population samples 2.76 T, 3.76 T, 4.76 T, 11.76 T, and 15.76 T are scattered in the eastern part of the island, partly in the outer dunes near the North Sea, partly in the inner dunes on the transitional zone towards the mud flats of the Wadden Sea. All samples are from dry grassland belonging to the *Koelerio-Coryneporetea* with influences from the *Molinio-Arrhenatheretea* and the *Plantaginetea majoris*, the latter influences indicating human disturbance apart from grazing and treading.

#### 4. THE COMPOSITION OF THE POPULATION SAMPLES OF TARAXACUM

Table 1 shows the species of *Taraxacum* encountered per sample. The number of *Erythrosperma* species per sample exhibits a fair amount of variation. In the Noordhollands Duinreservaat the number is 4–8, but mostly two or three species are dominant and several are less frequent. In Terschelling the number of species of the section *Erythrosperma* per sample is lower.

The specific composition of the dandelion samples is especially important in this connection because it shows quite clearly that a relatively large number of closely related species (of the same section) may occur sympatrically. This is of considerable significance because of repeatedly published reports of the occasional incidence or sexual processes in triploid dandelions. For the section *Vulgaria* this has been shown by SØRENSEN & GUDJONSSON (1946), for the section *Palustria* by MALECKA (1973), and for the section *Erythrosperma* by RICHARDS (1970a), but in our present investigation up to now no indications of any sexuality, hybridisation, or introgression have been found.

An explanation of the quantitative and qualitative composition of the *Taraxacum* flora of the habitats studied cannot be given as yet. Generally speaking, there is not much known of the ecology of the species of *Taraxacum*; this is presumably attributable to the relatively difficult recognisability of the species, which does not encourage any ecological studies. A fair amount of information concerning the ecology can be gleaned from phytosociological publications; in the Netherlands and regarding the section *Erythrosperma* in BOERBOOM (1957, 1960), DOING (1964, 1966), HAGENDIJK et al. (1975), and WESTHOFF & DEN HELD (1975). Our ecological records will be dealt with more extensively at some later date.

Table 1. Representation of the species of *Taraxacum* in the population samples. Per sample 50–100 individual plants were collected.

- very low: representation less than 5% in the sample  
 + few: representation 5–15% in the sample  
 ++ many: representation 15–50% in the sample

+++ numerous: representation 50–85% in the sample

The species above the horizontal line belong to sect. *Erythrosperma*, those below the line to sect. *Vulgaria*.

	Castricum			Heemskerk					Egmond aan Zee				Terschelling			
	1-75	3-75	6-75	7-75	8-75	11-75	14-75	15-75	18-75	20-75	21-75	22-75	4-75	2.76 T	3.76 T	11.76 T
<i>T. brachygloussum</i>							+									
<i>comixtum</i>			-							++	++		++			
<i>dunense</i>		++														
<i>lacistophyllum</i>		+					+							++		
<i>laetiforme</i>							+									
<i>obliquum</i>		+++		+++	+	+++	+									
<i>oxoniense</i>			+++		++	++	+	+	+							
<i>proximum</i>																
<i>rubicundum</i>	+++	++	+	+	+	+	+	+	+	++	+	+++	+	+++	+	
<i>scanicum</i>														++		
<i>silesiacum</i>																
<i>taeniatum</i>			+	+	+			+			+					
<i>tortilobum</i>	+	+	+							+	+	++		++	+	++
<i>T. dahlstedtii</i>											+					
<i>haematicum</i>																
<i>hamatum</i>																
<i>obtusilobum</i>																
<i>planum</i>																
<i>raunkiaeri</i>																
<i>indet.</i>									++	+	+		+			

Characteristic of the *vroonweiden* near Castricum are the *Erythrosperma* species *T. lacistophyllum*, *T. rubicundum*, and *T. tortilobum*. According to the phytosociological literature these forms exhibit a broad ecological amplitude. *T. tortilobum* is said to be a character species of the Order *Festuco-Sedetalia*, and *T. lacistophyllum* and *T. rubicundum* of the Alliance *Galio-Koelerion* (WESTHOFF & DEN HELD 1975). These species appear in most of our samples (see table 1). *T. tortilobum* is a species often encountered in localities where some anthropogenic influences prevail (HAGENDIJK *et al.* 1975). This explains its occurrence in the grazed or until recently grazed *vroonweiden*. The presence of *T. dahlstedtii* and *T. raunkiaeri*, species of the section *Vulgaria* preferring sandy soils (see 1.75), also points to human influence and cattle grazing. *T. obliquum* is here of incidental occurrence in sites where on open slopes with a southern exposure stands of vegetation related to the *Tortuleto-Phleetum* develop.

The dandelion flora of the samples from Egmond aan Zee contains a relatively large amount of species including representatives of the section *Vulgaria* pointing towards some human interference still noticeable in dunes around the fishing villages. The frequency of representation of *T. commixtum*, character species of the *Anthyllido-Silenetum nutantis*, and the closed grassy vegetation cover with manifest traces of damage by rabbits (WESTHOFF & DEN HELD 1975) are typical. Also *T. brachyglossum* is frequently encountered here, in a tetraploid form, and *T. tortilobum*, *T. rubicundum*, and *T. lacistophyllum* are again of common occurrence. *T. oxoniense* seems to prefer slopes with a northern exposure and is replaced on south-facing slopes by *T. obliquum* and *T. taeniatum*.

The samples from Oceaan do not show so many indications of human influences, *T. tortilobum* and the species belonging to sect. *Vulgaria* being but little represented. On south-facing slopes *T. obliquum* and *T. taeniatum* are dominant, on west-facing ones *T. oxoniense* and *T. rubicundum*.

The samples from Terschelling are somewhat poorer in species of *Taraxacum* than those from other localities. The frequent occurrence of *T. tortilobum* indicating anthropogenic interference is striking. Human activities are also manifest from the presence of species of sect. *Vulgaria*: *T. hamatum*, *T. haematicum*, and *T. obtusilobum* in 11.76 T. In the vegetation recordings there are several representatives of *Molinio-Arrhenatheretea* and *Plantaginea* indicating cattle grazing, treading, and manuring.

## 5. CYTOLOGICAL DATA

Table 2 shows the chromosome counts of species encountered in the present series of population samples investigated. The identifications of all the specimens studied were checked by Van Soest. Relevant literature references with the country of origin are included in this table. Only reliable counts obtained from high quality slides are reported.

In order to trace any regional variation, the chromosome number of each species was determined by examining material from as many localities as possible.

In a number of individual plants studied for their chromosome number, apart

Table 2. List of species with the corresponding chromosome counts recorded in the present study and as recorded in the literature<sup>1)</sup>.

Species	Number of sample	Number of mother plants	Number of seedlings	2n	2n (in literature)	Originating from	Author
brachygloum	8-75	2	8	24	16, 17, 18, 20, 24, 26, 28	Gr. Britain	Richards 1968, 1970b
					24	Sweden	Gustafsson 1935
					24	Letland	Chuhanova 1968
	20-75	1	3	32	24	D.D.R., Poland	Malecka 1969
	21-75	5	9, 1 <sup>2</sup>	32, 33 <sup>2</sup>	24	D.D.R.	Doll 1973a
	21-75	1	2	34			
commixtum	4-75	2	2	32	-	-	-
	20-75	1	2	32			
	21-75	1	2	32			
	22-75	1	2, 1	33, 64			
		1	1	32			
	6-75	1	3	24	-	-	-
	8-75	3	3	24			
dunense	4-75	1	1	24	24	Netherlands	Hou-Lju 1963
					24	Gr. Britain	Richards 1969
lacistophyllum	1-75	2	5	24	24	Sweden	Gustafsson 1932
	3-75	2	5, 1	24, 25	24	Gr. Britain	Richards 1969
	4-75	1	1	25	24	D.D.R.	Doll 1973a
	7-75	1	2, 1	24, 25			
	8-75	1	1	24			
	20-75	1	1	24	25	D.D.R., Poland	Malecka 1969
	3-76T	2	7	24			
	4-76T	1	5	24			
	11-76T	2	9	24			

laetiforme	11-75	1	1	24	-	-	Gustafsson 1932, 1933 Hou-Liu 1963
obliquum	3-75	1	7	24	24	Sweden	
	7-75	4	5	24	24	Netherlands	
	8-75	3	4	24			
	22-75	2	6	24			
oxoniense	6-75	5	6	24	32	Gr. Britain	Richards 1969
	7-75	2	5	24			
	8-75	3	7	24			
	15-75	1	1	24			
	18-75	1	1	24			
	20-75	1	1	24			
proximum	21-75	1	2	32	24	Gr. Britain D.D.R.	Richards 1969 Doll 1973a
rubicundum	1-75	1	1	24	24, 48	D.D.R.	Malecka 1969
	3-75	1	3	24	24	Gr. Britain	Richards 1969, 1970b
	6-75	4	5	24	24, 25	D.D.R.	Doll 1973a
	7-75	2	5	24			
	8-75	2	2	24			
	14-75	1	1	24			
	18-75	1	1	24			
	20-75	4	9	24			
	21-75	1	2	24			
	22-75	1	1	24			
	4-76T	1	4	24			
	11-76T	2	7	24			
	15-76T	1	3	24			
scanicum	2-76T	1	2	24	24	D.D.R. Poland	Doll 1973a Malecka 1967, 1969
					25		

silesiacum	7-75	1	2	24	23, 24 24	Gr. Britain C.S.S.R.	Richards 1968 Richards 1970a, Majovsky 1974 Doll 1973a Malecka 1969
	1-75	1	4	32	24 26	D.D.R. D.D.R.	
taeniatum	6-75	3	4	24	24	Netherlands Gr. Britain	Hou-Liu 1963 Richards 1968
	7-75	2	2, 7	24, 25	24		
	8-75	3	4	24	24		
	20-75	1	4	24	24		
tortilobium	1-75	3	7	24	24	Netherlands	Hou-Liu 1963
	3-75	1	1	24	24	D.D.R.	Doll 1973a
	6-75	3	4	24	25	France	Richards 1968
	7-75	1	3	24			
	22-75	1	3	24			
	4-76T	4	20	24			
	11-76T	3	15	24			
15-76T	1	4	24				

1. Intra-individual (e.g., somatic) variation is not accounted for.

2. The cipher behind the comma relates to the progeny and indicates the number of individuals in that progeny with the chromosome number indicated in the corresponding column.

from normal euploid cells, one or some with aneuploid cells were found (both hypo- and hyperploid ones were encountered). Since a certain variation in the somatic chromosome numbers, and the incidence of hyperploid cells in certain kinds of tissues is so often encountered, especially in seedlings, such variations found in *Taraxacum* are not specially mentioned (SWANSON 1975). All deviations in the number shown in *table 2* are, therefore, based on counts within one individual (or group of individuals) and indicate that such individuals deviate as a whole.

It appears from the table that the chromosome number of two species has been recorded for the first time, whilst in other species additional (*i.e.*, not previously encountered) numbers were found, which means that the regional variation in chromosome number within the section *Erythrosperma* is appreciably greater than was hitherto known.

### 5.1. Enumeration of the species with additional comments

*T. brachyglossum* Dahlst.:  $2n = 24, 32$  (see *figs. 1.1* and *1.2*).

RICHARDS (1970b) proved that in Great Britain this species is cytologically very variable. In our material no diploid (and sexual) individuals were encountered. The differentiation in triploid populations near Heemskerk and tetraploids ones (a novel record) near Egmond, two localities only about 15 km apart, is striking, especially since from widely scattered places on the European mainland only triploids were known. However, the species being not easily identifiable, incorrect naming resulting in an unwarranted record of the variation in the relevant literature cannot be excluded.

Among the tetraploids some hypertetraploid individuals were found, which elucidated that: (1) a specimen with  $2n = 33$  may originate as a single case among the normal ones ( $2n = 32$ ) in a progeny (the mother specimen having  $2n = 32$ ); and (2) a specimen produces, as far as could be ascertained, only a  $2n = 34$  progeny (*i.e.*, the mother specimen already has  $2n = 34$ ).

*T. commixtum* Hagl.:  $2n = 24, 32$  (first records for this species; see *figs. 1.3* and *1.4*).

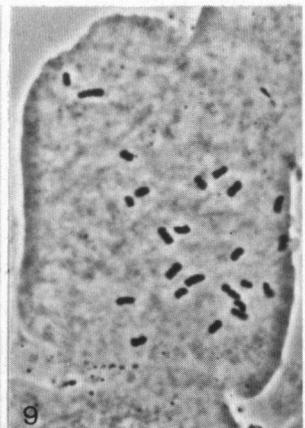
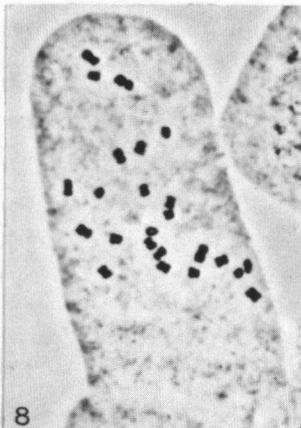
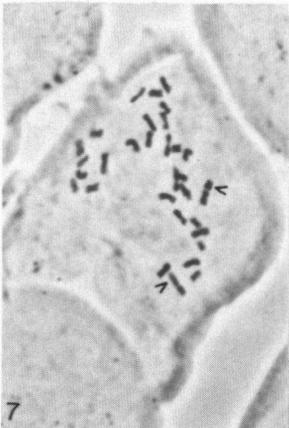
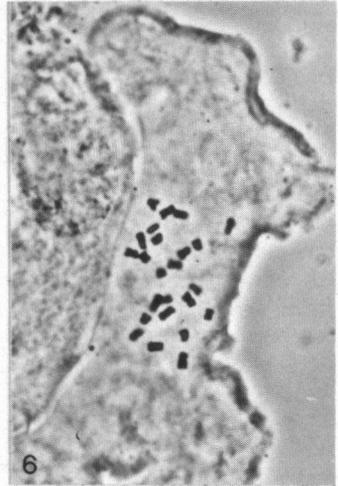
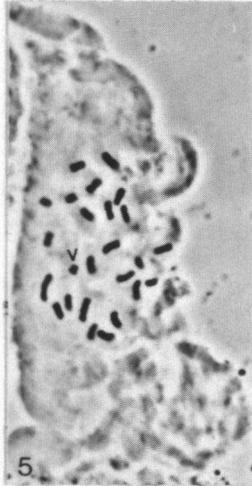
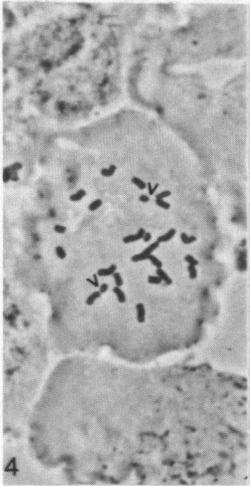
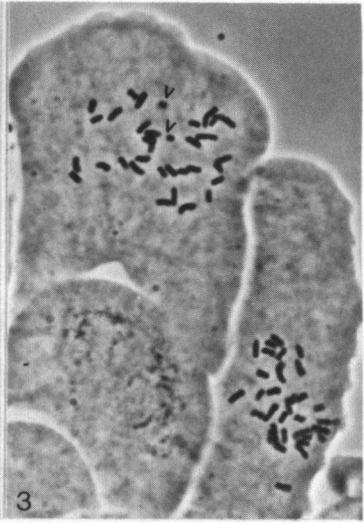
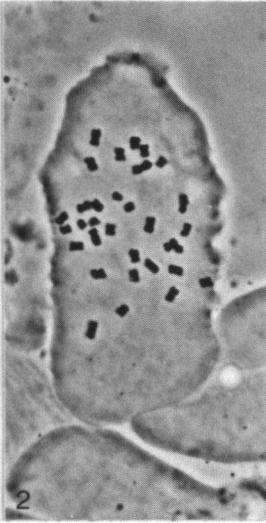
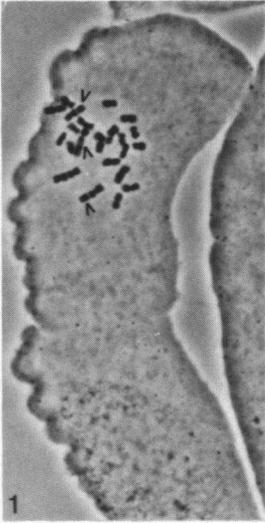
The cytological variation shows the same geographical distribution as in *T. brachyglossum*. *viz.*, triploids in the Heemskerk area and tetraploids in the vicinity of Egmond. *T. commixtum* is known to be rather polymorphic (HAGENDIJK et al. 1975). A study of the collected herbarium specimens revealed that although all the specimens undoubtedly belong to *T. commixtum*, there is, however, a morphological discontinuity correlated with the different chromosome numbers. All plants from Heemskerk are morphologically distinct from those found near Egmond. One must, therefore, consider the possibility of the occurrence of two different taxa instead of only one.

*T. dunense* V.S.:  $2n = 24$ .

Our findings confirm the older records.

*T. lacistophyllum* Dahlst.:  $2n = 24(25)$ .

In contrast to many populations from the DDR and Poland which consist entirely of hypertriploids with  $2n = 25$  (MALECKA 1969), our studies showed that in the



Dutch populations studied  $2n = 25$  individuals are only occasionally encountered (see fig. 1.5).

*T. laetiforme* Dahlst.:  $2n = 24$  (first record for this species).

This species was only sporadically met with.

*T. obliquum* (Fr.) Dahlst.:  $2n = 24$ .

The presence of only triploid individuals without any deviation confirms previous records of the chromosome number.

*T. oxoniense* Dahlst.:  $2n = 24$  (see fig. 1.6).

The triploidy found in Holland (a new record for the species) is not in agreement with the tetraploidy found in British populations (RICHARDS 1969). DOLL (1973b), in his revision of the section *Erythrosperma*, mentions this taxon only among the *species dubiae* because the original description and the type specimen do not give any information concerning the colour of the achenes. It may well be, therefore, that the various students of dandelions, when referring to this species, do not necessarily always deal with the same taxon.

*T. proximum* (Dahlst.) Raunk.:  $2n = 32$ .

It is rather curious that the tetraploid number we found (deviating from that reported from elsewhere: Great Britain, C.S.S.R., D.D.R.:  $2n = 24$ ) is localised again in the area S. of Egmond (compare *T. brachyglossum* and *T. commixtum*).

*T. rubicundum* Dahlst.:  $2n = 24$ .

In the 44 specimens studied, which came from a total of 13 different sites, no indication of the incidence of hypertriploidy (DOLL 1973a) was found. In view of our ample number of observations it is extremely doubtful whether hypertriploids occur in our dune area at all. The hexaploid specimen recorded by MALECKA (1969) is most probably an incidental deviation.

*T. scanicum* Dahlst.:  $2n = 24$ .

In agreement with DOLL (1973a), also in our region there is no confirmation of the number of  $2n = 25$  recorded in Polish material.

*T. silesiacum* Dahlst.:  $2n = 24, 32$  (see fig. 1.7).

Also in this taxon we found a diversity in the ploidy level within a relatively small area: triploids and (a novel record) tetraploids. Again no confirmation was found of the occurrence of hypertriploidy ( $2n = 26$ ) as recorded from 5 different places in Thuringia by MALECKA (1969). DOLL (1973a) did not find any aberrant chromosome numbers either in plants from elsewhere in the D.D.R.

*T. taeniatum* Hagl.:  $2n = 24(25)$  (see fig. 1.8 and 2.1, 2, 3).

Fig. 1: Metaphase plates of some of the species studied:

- 1.1. *T. brachyglossum*  $2n = 24$ , note the very large SAT's and secondary constrictions;
- 1.2. *T. brachyglossum*  $2n = 32$ ;
- 1.3. *T. commixtum*  $2n = 32$ , note (as indicated) the two distant chromosome segments;
- 1.4. *T. commixtum*  $2n = 24$ , see the indicated large SAT's;
- 1.5. *T. lacistophyllum*  $2n = 25$ , the indicated 25th chromosome could be a segment broken off from the mother chromosome;
- 1.6. *T. oxoniense*  $2n = 24$ ;
- 1.7. *T. silesiacum*  $2n = 32$ , with large segments;
- 1.8. *T. taeniatum*  $2n = 24$ , compare fig. 2.1–2.3 for variation in SAT's;
- 1.9. *T. tortilobum*  $2n = 24$ .

In one progeny (of 6.75), apart from eutriploids, numerous  $2n = 25$  plants were found. If the latter can originate simultaneously (may be by a genetic predisposition of the eutriploid mother) the possibility arises that whole populations of such  $2n = 25$  plants could develop. This could not be concluded from the scant representation of such hypertriploid individuals dealt with elsewhere in the present study, e.g. *T. lacistophyllum*. Such a mechanism might contribute appreciably to the dynamics of the taxon as regards its variability, provided that the phenomenon is indeed attributable to true tetrasomy and not to a breakage of one of the chromosomes. We shall return to this point in the discussion.

*T. tortilobum* Florst.:  $2n = 24$ .

None of the 57 specimens (from 8 sites) studied showed any variation in their triploidy, which renders the incidence in Holland of the  $2n = 25$  type recorded from France and from Spain (RICHARDS 1968) most unlikely. The number of SAT chromosomes varied appreciably (see fig. 1.9).

#### 4.2. Some notes on chromosome morphology

During the present investigation some attention has been given to the chromosome morphology, especially as regards the presence of satellites and of secondary constrictions such as mentioned by, e.g., MALECKA (1962) in her discussion of karyotypes in *Taraxacum*.

"True" satellites in the form of relatively small and dot-like appendages of some of the chromosomes were not observed, but much larger elements, up to half the length of the arms, were seen which are distinctly separated from the rest of the chromosome and may be regarded as satellites. This type of chromosome is mentioned by MALECKA (1969) as her Type VI although in the illustrations of the metaphase plates in her paper the size of the satellite is not in proportion to the given description (they are much smaller and almost dot-like).

Secondary constrictions have also been noticed in our material, the arm segment cut off being of about the same size as the above-mentioned satellites and only distinguishable by the fact that the separation from the chromosome is only a constriction resembling a centromere and not a space between the parts of the arm.

In practice we could not always succeed in distinguishing these two types consistently because the variation in the mode of constriction was too great. Since such typifications are sometimes used in karyological publications, the records of the presence of large satellites well separated from the remainder of the chromosome are shown in table 3 (compare also the figs. 1.1 to 1.9).

The records are given per species, i.e., they are from all individuals studied combined, and indicate the number and the variation of the number, respectively, of SAT chromosomes encountered. The variation did not appear to be correlated with certain population samples, which means that only on rare occasions per species (or per sample, respectively) a constant number was recorded.

## 6. DISCUSSION

It was found that in the area studied from 4 to 8 species of the section *Erythro-*

Table 3. SAT-chromosome frequencies in some species of sect. *Erythrosperma*.

Species	Present study		Richards 1968		Malecka 1962	
	2n	no. of SAT-chr.	2n	no. of SAT-chr.	2n	no. of SAT-chr.
brachyglossum	24	3	24	-	24	3
	32	0-1				
commixtum	32	0-3				
	24	1-3				
lacistophyllum	24	0-4			25	4
	25	4				
obliquum	24	0-3				
oxoniense	24	2-3	32	-		
proximum	32	1				
rubricundum	24	0-3	24	-	24	3
scanicum	24	0-2				
silesiacum	24	1	24	0-3	26	1
	32	1				
taeniatum	24	1-2	24	-		
	25	1-2				
tortilobum	24	0-3	25	2-3		

*sperma* may occur sympatrically; the eight species form one-third of all dandelions of that section recorded from the Netherlands. According to RICHARDS (1970a) the co-occurrence of more than two or three dandelions of that section is most unusual in Britain, and he considered the presence of 9 species in one single habitat in Slovakia to be exceptional. However, in the Netherlands, in localities in the dunes, the occurrence of up to 8 taxa of that section is not at all rare; the additional presence of the not directly (ecologically) related *Vulgaria* is not even taken into account.

The results of our studies indicated that one area may be much richer in *Taraxacum* species than another region that is nevertheless comparable in several respects: the dunes of Terschelling are upon the whole not so rich in species of *Erythrosperma* as those of the Noordhollands Duinreservaat (the transitional zones towards the mud flats excepted). It has furthermore appeared that in the dunes the *Taraxacum* flora may differ along relatively short distances even if there are no conspicuous differences in vegetation cover, soil conditions, or exposure. Possible explanations could be: chance happenings or effects, associated with the appreciable possibilities of fruit dispersal (which might be particularly of importance for species represented in low frequencies) and the small-scale heterogeneity of the biotype.

For a comparison of the diversity of dandelion taxa per habitat in phytogeographically similar areas the following points may be relevant:

(a) The surface area of the plots studied: if it is too small, especially the less frequently occurring species, although occurring in that habitat, may not be re-

corded (compare the minimum sample plot area in phytosociology: BRAUN-BLANQUET 1964).

(b) The correct naming of the species, which is especially important when morphologically very similar species grow sympatrically and misidentifications are likely to occur.

(c) The type of habitat: further studies have shown that, generally speaking, in not much disturbed sandy biotopes (in which particularly species of the section *Erythrosperma* occur), fewer species are found than in grassland types in which the *Vulgaria* dandelions predominate; it is of importance to note in this connection that so far 23 species of Sect. *Erythrosperma* and an estimated 150 of Sect. *Vulgaria* have been recorded from the Netherlands. From our investigations and from published reports it has become quite clear that many dandelion taxa are ecologically closely related and frequently sympatric in certain habitats. This may have important consequences for any gene-flow between and for the identity of such species; conceivably the incidence of a sometimes relatively large number of indeterminate individuals may also have something to do with it. Our future research will, therefore, pay a great deal of attention to the possible occurrence of sexual processes in *Taraxacum* populations.

As regards the chromosome numbers, the value of a fine-meshed system of sampling has once more been proved convincingly by the fact that both local and regional variation in number came to light (see also RICHARDS, 1968). Within the region of study variation was sometimes noticed, but also several differences between our results and previously published counts were found.

Two categories of deviating results are especially noteworthy, *viz.*,

(1) Species in which slight differences were found between our counts and those recorded elsewhere, which differences (*e.g.*, between  $2n = 24$  and  $2n = 25$  or 26) can relatively easily be explained by deviations fixed in the agamospermic mode of reproduction and rendering the competitive capacities of the genome strong enough to maintain itself. The populations or population groups originated in this way might have a local distribution. From the data regarding, *e.g.*, *T. taeniatum* it has appeared that hypertriploid individuals may indeed develop in the progeny of a eutriploid mother plant (compare in this connection also, *e.g.*, SØRENSEN & GUDJONSSON 1946 who found spontaneous hypotriploids). As a characteristic feature of a certain species hyperploidy is not a useful taxonomic criterion, however.

(2) Species with several ploidy levels. Such taxa may be of greater importance for the unravelling of the speciation mechanisms in *Taraxacum* than such as those mentioned sub 1. It is known that tetraploids may have originated from triploids when, in contrast to the normal apomictic mode of reproduction, an "unreduced egg cell" becomes fertilised by a haploid gamete (MÜLLER 1972; MALECKA 1973). A new tetraploid form may arise, for instance, which is directly related to the "old" species, provided the constituting gametic cells both belong to that species. This need not to be the case, however. In such circumstances the presence of two separate biological entities cannot be precluded, although they may be very similar in appearance and were, therefore, referred to the same species by taraxa-

cologists. It is rather probable that in spite of the morphological resemblance such forms have different ecological amplitudes. In this connection, the data concerning *T. brachyglossum*, *T. commixtum* and *T. silesiacum* are rather suggestive, because these taxa all occur in both triploid and tetraploid populations within the rather limited area under investigation. This opens up a promising possibility of a thorough investigation of the genetical and ecological aspects of the incidence of such sympatric populations with different ploidy levels. This situation even gains an extra dimension by the fact that most of the tetraploid populations in question, irrespective of their specific identity, occur in the Egmond area (localities 20., 21., and 22.75) whereas the corresponding triploids are centred around Heemskerk (e.g., loc. 6., 7. and 8.75). Conceivably, the anthropogenic influences so manifest in the Egmond area and resulting in a special character of the vegetation, referred to the *Koelerion-Silene* landscape by DOING (1964), may play a role.

As regards the SAT chromosomes and the secondary constrictions, the following comment seems appropriate. During our karyological observations we rather frequently noticed that the severed fragment, as a rule nearly half as long as the arm involved, was lying so far from the remainder of the chromosome, and was sometimes more or less twisted in the plain of the metaphase, that there was some considerable doubt whether that fragment was still connected or whether it was a separately functioning (B-)chromosome (as already intimated by RICHARDS 1968; see also our *figs. 2.1, 2.2, and 2.3*). For this reason the present authors do not preclude the possibility that both in our own studies and in those of other workers the count of 25 (or 26 as the case may be) chromosomes was in fact unwarranted and was (or is) incorrectly recorded for the individual specimen (or the population or species) examined. It is not impossible that a very stringent uniformity of the

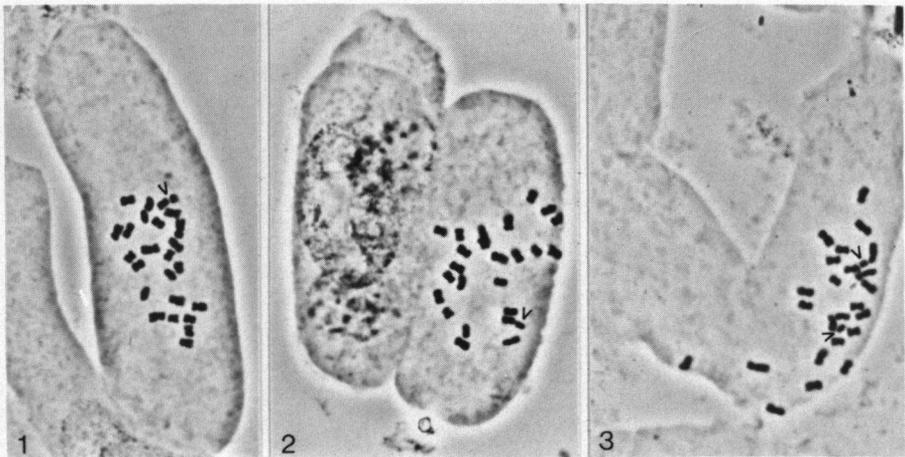


Fig. 2: Metaphase plates of *T. taeniatum*:

2.1. normal  $2n = 24$ , one big SAT-chromosome;

2.2. the satellite slightly turned and nearly as large as the remainder of the chromosome (arrow);

2.3. two large SAT's, one of which rather distant (arrow).

pretreatment procedures before the actual squashing might prevent such uncertainties. The procedures followed during the present study were not so stringently uniform and this applies most probably to the methods followed by other workers. This renders the records in our *table 3* somewhat doubtful as far as the correlation between the specific status and the number of SAT chromosomes is concerned. Of all our counts only those of *T. lacistophyllum* (which was, incidentally, only occasionally encountered) were consistent ( $2n = 25$  with always 4 SAT chromosomes). One must also accept that all difficulties associated with the construction of karyograms of *Taraxacum* (GUSTAFSSON 1932; SØRENSEN & GUDJONSSON 1946: 8 chromosome types; MALECKA 1962: 6; RICHARDS 1972: 10; SINGH *et al.* 1974: 16) may have something to do with the above-mentioned difficulties encountered when one studies the chromosome morphology.

#### ACKNOWLEDGEMENTS

We are especially indebted to Professor J. L. van Soest, A. Hagendijk and H. A. Zevenbergen who did and checked so many identifications, and to W. Everts and A. G. VFengler who did parts of the filed work and the analyses. We expressly wish to state that without their co-operation the present study could never have been so fruitful. The direction of the Noordhollandse Duinreservaat deserves our gratefulness for all facilities granted to us and our collaborators. The technical assistance of our staff members L. Dijkhuizen, H. Koerts Meyer, and J. R. Lindeboom also deserves our indebtedness. Professor A. D. J. Meeuse again screened our manuscript and took care of the English translation.

#### REFERENCES

- BOERBOOM, J. H. A. (1957): Les pelouses sèches des dunes de la côte néerlandaise. *Acta Bot. Neerl.* **6**: 642–680.
- (1960): *De plantengemeenschappen van de Wassenaarse duinen*. Thesis, Wageningen.
- BRAUN-BLANQUET, J. (1964): *Pflanzensoziologie*. Wien.
- CHUHSANOVA, N. A., L. T. SOECHANKOVA & T. V. ALEXANDROVA (1968): Data on karyology of the family Compositae Giseke. *Citologia* **10**: 198–206.
- DOING KRAFT, H. (1954): L'analyse des carrés permanents. *Acta Bot. Neerl.* **3**: 421–424.
- DOING, H. (1964): Recreatie en natuurbescherming in het Noordhollands Duinreservaat. Supplement 2: Vegetatie. *Ithon Meded.* **69**. Arnhem.
- (1966): Beschrijving van de vegetatie der duinen tussen IJmuiden en Camperduin. *Meded. LHS, Wageningen* **66**: 13.
- DOLL, R. (1973a): Revision der sect. *Erythrosperma* Dahlst. emend. Lind. f. der Gattung *Taraxacum* Zinn. (Teil 1). *Feddes Rep.* **83**: 673–740.
- (1973b): Revision der Sektion *Erythrosperma* Dahlst. emend. Lindb. f. der Gattung *Taraxacum* Zinn. 2. *Feddes Rep.* **84**: 1–180.
- (1974): *Die Gattung Taraxacum*. Wittenberg Lutherstadt.
- FÜRNKRANZ, D. (1960): Cytogenetische Untersuchungen an *Taraxacum* im Raume von Wien. *Österr. Bot. Z.* **107**: 310–350.
- GUSTAFSSON, A. (1932): Zytologische und experimentelle Studien in der Gattung *Taraxacum*. *Hereditas* **16**: 41–62.
- (1933): Über die Teilung der Embryosackmutterzelle bei *Taraxacum*. *Bot. Notiser* **86**: 531–534.
- (1935): Primary and secondary association in *Taraxacum*. *Hereditas* **20**: 1–31.
- GUSTAFSSON, A. (1937): The occurrence of a sexual population within the apomictic *Taraxacum* vulgare group. *Bot. Not.* **90**: 332.

- HAGENDIJK, A. J.-L. VAN SOEST & H. A. ZEVENBERGEN (1975): *Taraxacum*. In: *Flora Neerlandica* IV, 9. Amsterdam.
- HEUKELS, H. & S. J. VAN OOSTSTROOM (1975): *Flora van Nederland*. 18th ed. Groningen.
- HOFSTEN, C. G. VON (1954): *Studier över släktet Taraxacum Wigg. med särskild Hänvisning till gruppen Vulgaria Dt. i Skandinavien*. Thesis, Stockholm.
- HOU-LIU, S. Y. (1963): The chromosome counts of some *Taraxacum* species. *Acta Bot. Neerl.* **12**: 76–83.
- MAJOVSKY, J. et al. (1974): Index of chromosome numbers of Slovakian flora. Part 3. *Acta F.R.N. Univ. Comen.-Bot.* **22**: 1–20.
- MALECKA, J. (1961): Studies in the mode of reproduction of the diploid endemic species *Taraxacum pienicum* Pawl. *Acta Biol. Crac. Series Bot.* **4**: 25–42.
- (1962): Cytological studies in the genus *Taraxacum*. *Acta Biol. Crac. Series Bot.* **5**: 117–138.
- (1967): Cyto-embryological studies in *Taraxacum scanicum* Dt. *Acta Biol. Crac. Series Bot.* **10**: 195–206.
- (1969): Further cytotaxonomic studies in the genus *Taraxacum* section *Erythrosperma* Dt. I. *Acta Biol. Crac. Series Bot.* **12**: 57–70.
- (1973): Problems of the mode of reproduction in microspecies of *Taraxacum* section *Palustria* Dahlstedt. *Acta Biol. Crac. Series Bot.* **16**: 37–84.
- MÜLLER, U. (1972): Zytologisch-embryologische Beobachtungen an *Taraxacum*-Arten aus der Sektion *Vulgaria* Dahlst. in der Schweiz. *Ber. Geobot. Inst. Eidg. Tech. Hochsch. Stift. Rübel, Zür.* **41**: 48–55.
- NIJS, J. C. M. DEN (1974): Biosystematic studies of the *Rumex acetosella*-complex. I. Angiocarpy and chromosome numbers in France. *Acta Bot. Neerl.* **23**: 655–675.
- RICHARDS, A. J. (1968): *The biosystematics of Taraxacum*. Ph.D. Thesis, University of Durham.
- (1969): In: Löve, A. I.O.P.B. chromosome number reports XXIII. *Taxon* **18**: 560–562.
- (1970a): Observations on *Taraxacum* section *Erythrosperma* DT. em. Lindb. fil. in Slovakia. *Acta F.R.N. Univ. Comen.-Bot.* **18**: 81–120.
- (1970b): Eutriploid facultative agamospermy in *Taraxacum*. *New Phytol.* **69**: 761–774.
- (1972): The karyology of some *Taraxacum* species from alpine regions in Europe. *Bot. J. Linn. Soc.* **65**: 47–59.
- & P. D. SELL (1976): *Taraxacum* in: *Flora Europaea* **4**: 332–343.
- SINGH, D. et al. (1974): Cytological studies in the genus *Taraxacum* Weber. *Proc. Indian Acad. Sci., Sect. B* **80**: 82–91.
- SOEST, J. L. VAN (1958): The phytogeography of *Taraxacum* with special reference to Europe. *Blumea Suppl. IV*: 60–67.
- (1963): *Taraxacum* species from India, Pakistan and neighbouring countries. *Wentia*: 1–91.
- SOLBRIG, O. T. & B. B. SIMPSON (1974): Components of regulation of a population of dandelions in Michigan. *J. Ecol.* **62**: 473–486.
- SØRENSEN, TH. & G. GUDJONSSON (1946): Spontaneous chromosome-aberrants in apomictic *Taraxaca*. Morphological and cyto-genetical investigations. *Dansk Selsk. Biol. Skrifter* **4**(2): 1–48.
- SWANSON, C. P. (1957): *Cytology and Genetics*. Englewood Cliffs.
- TSCHERMAK-WOESS, E. (1949): Diploides *Taraxacum vulgare* in Wien und Niederösterreich. *Österr. Bot. Z.* **96**: 56–63.
- WESTHOFF, V. & A. J. DEN HELD (1975): *Plantengemeenschappen van Nederland*. Zutphen.